# Simulations of Metallic Nuclear Fuel Casting

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As part of the Global Nuclear Energy Partnership (GNEP), Idaho National Laboratory (INL) is designing a bench-scale casting furnace to develop the capability to cast thin rods of a uranium-plutonium-zirconium fuel alloy. The Telluride project [1] team and the MST-6 foundry at LANL are supporting this design effort by running simulations of casting processes to determine furnace design features and operability limits for the fuel casting process.

Fuel rods are long and thin, 380 mm long and 4.4 mm in diameter. The ultimate goal is to cast as many as 60 rods in a single pour. An initial bench-scale process is designed to cast three rods, as shown in Fig. 1. The multi-physics code Truchas is being used to simulate coupled fluid flow, heat transfer, and phase change, first for a single rod and subsequently for the three-rod bench-scale process.

The mold and crucible are made of graphite and heated by induction coils. Given the high thermal conductivity of the graphite, the mold must be filled very quickly to obtain a homogeneous casting. To achieve the needed fill rates, the mold will be evacuated and the metal injected under pressure. The simulation results show that for a constant pressure condition of 5 Kpa at the inlet (and nominal conditions elsewhere), the casting will freeze too quickly, preventing the mold from completely filling (Fig. 3). The simulations predict that the mold will fill successfully with an inlet pressure of 100 Kpa.

Future applications of Truchas to this problem will include operability studies to determine process parameters, sensitivity studies to quantify the accuracy required for pressure and temperature data, and improved material property models.

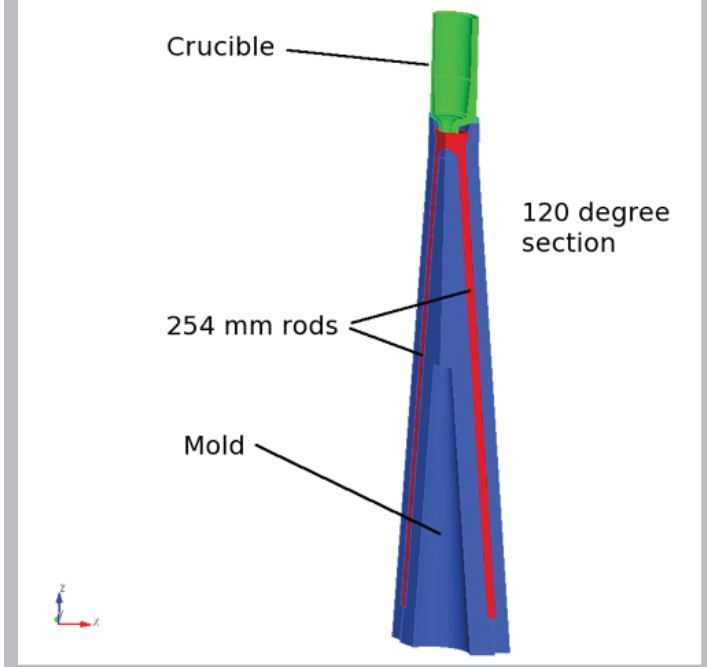


*Fig. 1. Geometry of the proposed bench scale mold and crucible.*

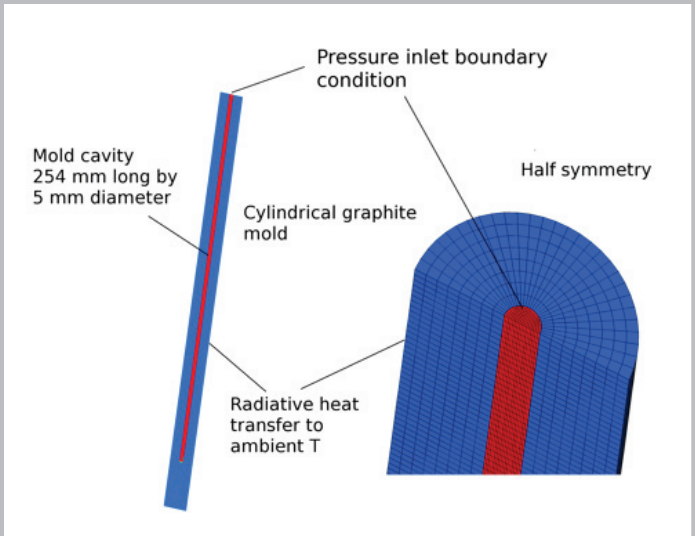


*Fig. 2. Preliminary, single rod-filling simulation.*

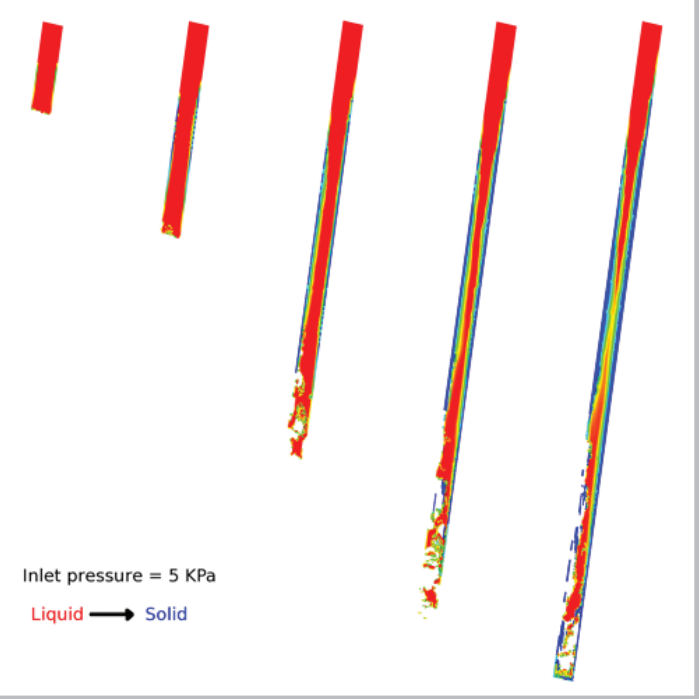


*Fig. 3. Time sequence images of a rod-fill simulation. An inlet pressure of 5 KPa does not allow complete filling of the mold before solid metal obstructs the flow, which can be seen clearly in the last image. The radial direction is magnified 3x relative to the length to show more detail.*

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[1] Telluride project: http://telluride.lanl.gov.

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